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Report 2410

A FIELD BLENDING GUIDE FOR IMPROVING THE LOW TEMPERATURE PROPERTIES OF GROUND DIESEL FUELS

June 1984

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United States Army
Belvoir Research & Development Center
Fort Belvoir, Virginia 22060

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 2410
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): A FIELD BLENDING GUIDE FOR IMPROVING THE LOW TEMPERATURE PROPERTIES OF GROUND DIESEL FUELS
5. TYPE OF REPORT & PERIOD COVERED
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s):
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8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Fuels & Lubricants Division; Materials, Fuels, & Lubricants Laboratory; US Army Belvoir Research and Development Center; Fort Belvoir, VA 22060-5166
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: P.E. 6.27.33, AH20 VM

11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Belvoir Research an Development Cent[illegible]; ATTN: STRBE-VF; Fort Belvoir, VA 22060-5166
12. REPORT DATE: June 1984
13. NUMBER OF PAGES: 52

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Diesel Fuel Grade DF-2
Low Temperature Operability
Paraffinic Hydrocarbons
Wax Content
Cloud Point
Tenth Percentile Minimum Value
Prevailing Ambient Temperature
Blending Fuels
Blending Ratios
Blending Procedures
Field Test Procedure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A field test to determine the Cloud Point of DF-2 diesel fuels has been developed to aid in the low temperature operation of diesel-powered vehicles and equipment. Some low temperature operability problems can be traced to the normal and/or branched hydrocarbons in the fuels which at low temperature will precipitate and become insoluble. The point when wax crystals first begin to precipitate is called the Cloud Point. Low temperature operability of vehicles and equipment is determined by the Cloud Point of the fuel. The procedures outlined in the report instruct the soldier in the field how to determine the Cloud Point, blending fuels to use, blending ratios, and blending procedures. This report should alleviate some of the low temperature operability problems experienced in the past.

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CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (CONTINUED)

TABLES

A FIELD BLENDING GUIDE FOR IMPROVING

THE LOW TEMPERATURE PROPERTIES OF GROUND DIESEL FUELS

I. INTRODUCTION

When vehicles/equipment experience cold weather operability problems, the fuel used is usually considered to be the source. For vehicles/equipment to operate satisfactorily at low temperatures, the following variables are inter-related: fuel, equipment/vehicles, and user/field practices. Cold weather inoperability occurs as a result of the variables individually and/or collectively not being adequately considered. This report focuses on the fuel, however, and ways to improve its low temperature properties.

The manner in which diesel fuels are blended at the refinery will control their low temperature properties.[1] Fractions that contain normal and/or branched paraffinic hydrocarbons will have poorer low temperature properties because of the tendency for these waxy/paraffinic hydrocarbons to precipitate and become insoluble with decreasing temperatures.

Diesel fuel meeting requirements of Federal Specification VV-F-800 Grade DF-2 has a wax content of approximately 6 to 8 percent. At normal temperatures, this wax will be in solution, but at low temperatures some of the wax will precipitate. The point when wax crystals first begin to precipitate is called the Cloud Point. Low temperature operability of vehicles and equipment is determined by the Cloud Point of the fuel. It is at the Cloud Point when vehicle/equipment inoperability probably will occur first.[2] For this reason, vehicles and equipment are generally referred to as being "Cloud Point limited."

Vehicles and equipment will be operable if the ambient temperature is above the Cloud Point of the diesel fuel. Because of this, caution must be taken so that fuel intended for use in spring, summer, and fall will not be used in the winter (low ambient temperatures). Current specifications for defining the low temperature use limits of diesel fuel are based on the Tenth

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[1] F. J. Pass, C. Csoklish, and K. Wastl, Proceedings of the Seventh World Petroleum Congress, Volume III, Applications and New Uses, Part 2, p. 129 (1967).

[2] Mobil Tech Topics, File No. 2-3, Mobil Research and Development Corporation.

Percentile Minimum value.[3] This has been developed to predict anticipated low temperatures. These Tenth Percentile values may not account for all unexpected changes in prevailing ambient temperatures, as unusually low temperatures are always considered to be extremes. Since user and supply personnel generally know from past experience the low winter temperatures in their locality, they should be qualified in selecting and/or specifying the Cloud Point with the aid of the Tenth Percentile Minimum value.

The Tenth Percentile Minimum values for specifying Cloud Point limitation are provided in the Federal Specification VV-F-800, "Fuel Oil, Diesel," and in ASTM D975 Standard for Diesel Fuel. If the fuel is to be procured in large (i.e., bulk) quantities and turnover time is slow, it is essential that the specified Cloud Point value be at least equivalent to or lower than the prevailing ambient temperature anticipated during the coldest time within that period of use. When the Cloud Point is above or anticipated to be above the prevailing ambient temperature, provision must be made to "winterize" the fuel. Diesel Fuel DF-2 can be "winterized" by blending kerosene, other solvents, or low Cloud Point fuels to effectively dilute the total wax content of the fuel to be used.

It is essential that blending be done *before* the onset of any anticipated low temperatures because complete mixing of the two fuels must occur in order to effectively lower the Cloud Point.

Flow improvers and pour-point depressants which are in general use within the civilian sector should not be added to diesel fuels. They are intended primarily to improve the low temperature operability of burner and distillate fuels. However, they do not change the Cloud Point value.[4] Since cold weather operability of vehicles and equipment is limited by the Cloud Point, these additives will not be effective in solving any cold weather problems. Further, their effectiveness in lowering the Cloud Point is based upon their responsiveness with the blending fractions used by refiners and terminal operators. These additives are not recommended or permitted to be used with diesel fuel procured under Federal Specification VV-F-800.

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3 Federal Specification VV-F-800, "Fuel Oil, Diesel."

4 N. B. Drury, Chevron Technical Bulletin No. 15 (1982).

II. RESULTS AND DISCUSSION

1. Blending Fuels. Fuels and solvents which can be used as "blending fuels" are shown in Table 1. All of the blending fuels have Cloud Points considerably below that of DF-2. No other fuels or solvents should be used for blending with DF-2. A potentially dangerous safety condition can be created by blending a low flash point fuel such as gasoline (aviation or automotive) or naphtha-base turbine fuel (JP-4 or Commercial Jet B). The fuels and solvents shown in Table 1 have flash points above 100° F.

Table 1. Fuels and Solvents With Flash Points Above 100° F

Fuel Type	Specification	NATO Code Number	NSN
Kerosene	ASTM D3699 (Supercedes VV-K-211 and VV-K-220)	F-58	9140-00-247-6748 (bulk) 9140-00-273-2394 (drum)
Turbine Fuel	MIL-T-5624, JP-5	F-44	9130-00-273-2379 (bulk)
Turbine Fuel	MIL-T-83133, JP-8	F-34	9130-01-031-5816 (bulk)
Commercial Turbine Fuel, Jet-A	ASTM D1655	N/A	9130-00-359-2026 (bulk)
Commercial Turbine Fuel, Jet A-1	ASTM D1655	N/A	9130-00-753-5026 (bulk)
High Flash Point Calibration Fluid	MIL-F-27351	N/A	6850-00-754-2670 (drum)
Dry Cleaning Solvent, Type II	P-D-680	S-573	6850-00-274-5421 (5-gal can) 6850-00-285-8011 (drum) 6850-00-637-6135 (bulk)

Kerosene is used by both the Military and commercial sector as a heating fuel. It may be obtained at a motor pool in limited quantity and at commercial fuel oil outlets in larger quantities. Some commercial PX service stations also carry it.

JP-5 is the type of turbine fuel used by the Navy and thus usually is available only at Navy bases and Naval Air detachments. JP-8 is being considered as a replacement for JP-4 in Army and Air Force turbine-powered aircraft; it is available only at certain OCONUS bases. At the present time, the USAF has converted to JP-8 in the United Kingdom.

Jet A is similar to JP-8 except for a higher freeze-point requirement (i.e., JP-8 specifies a -47° C maximum freeze point whereas Jet A specifies a -40° C maximum requirement) and the absence of additive requirements for corrosion inhibitor, static dissipator, and icing inhibitor. Jet A generally is available within CONUS at all airports and is used by the commercial US air carriers for all flights within CONUS.

Jet A-1 is identical to JP-8 except for the absence of additive requirements for the static dissipator, corrosion inhibitor, and icing inhibitor. Jet A-1 is the fuel used by all commercial carriers and is available at all commercial airports OCONUS. It may be found at some airport facilities within CONUS where transoceanic flights depart.

High Flash Point Calibration Fluid generally will not be available except at special testing locations.

Dry Cleaning Solvent may be available at the base motor pool, Class II supply point, PX dry cleaning plants, and in some industrial dry cleaning plants. The solvent must be hydrocarbon base and contain *no* halogenated compounds.

Within the NATO environment, additional fuels may become available for use with NATO F-54 diesel fuel. Although diesel fuel meeting the requirements of F-54 (VV-F-800, Grade DF-2/OCONUS) has a lower Cloud Point requirement than that of DF-2 which is used within CONUS (i.e., F-54 specifies a -13° C maximum Cloud Point limit), there may be occasions when blending of this fuel is arranted. The fuels in Table 2 are shown with the appropriate NATO stock numbers.

Souces of blending fuel ingredients should be planned well in advance of the winter season. If sufficient storage space is available, blending ingredients can be kept on hand until needed.

Table 2. Blending Fuels for Use Within the NATO Environment

Fuel Type	US Specification	NATO Code Number	NSN
Kerosene	ASTM D3699	F-58	9140-99-910-5054 (bulk)
Turbine Fuel, Aviation	MIL-T-83133, JP-8	F-34	9130-99-220-1036 (bulk)
Turbine Fuel, Aviation without FSII*	MIL-T-83133, JP-8	F-35	9130-99-943-1771 (bulk)
Turbine Fuel, Aviation	MIL-T-5624, JP-5	F-44	9130-99-224-9717 (drum) 9130-99-220-2148 (bulk)
Turbine Fuel, Aviation without FSII*	MIL-T-5624, JP-5	F-43	9130-99-224-9717 (drum) 9130-99-220-2148 (bulk)

*FSII—Fuel System Icing Inhibitor.

2. Determination of Blending Ratios. Before a decision is made to add blending fuel to DF-2, the following information must be available: (a) the Cloud Point(s) of each of the batches or lots of DF-2 in storage containers, refueling vehicles, or using vehicles and equipment; and (b) the predicted temperature drop sustained for a period of time corresponding to the scheduled operation of the user vehicles and equipment. If the value predicted from (b) is significantly lower than the Cloud Point(s) from (a), low temperature operational problems will probably occur and fuel blending is recommended.

The Cloud Point of the DF-2 sometimes can be obtained from vendor records, although the vendor is not required to supply the Cloud Point under the terms of VV-F-800. Most base fuel laboratories can determine the Cloud Point in a few minutes; if no laboratory is available, the Cloud Point can be determined by the field method described in Section III of this report. It is important that the Cloud Point of *each* lot or batch be known; one lot may be distributed among many vehicles and storage containers, or a vehicle may contain more than one lot.

Once the Cloud Point(s) is known, the determination of blending ratio(s) can be obtained by referring to Table 3, 4, 5, or 6.

Table 3. Blending Ratio for +20° to +10° F

Desired Cloud Point (°F)	Initial Cloud Point (°F) 20	18	16	14	12	10
	Gallons of Blending Fuel to Add to 100 Gallons DF-2					
20	0					
18	10	0				
16	21	10	0			
14	32	21	10	0		
12	43	32	21	10	0	
10	62	48	34	22	12	0

Table 4. Blending Ratio for +8° to -25° F

Desired Cloud Point (°F)	Initial Cloud Point (°F)																	
	8	6	4	2	0	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20	-22	-24	-26
	Gallons of Blending Fuel to Add to 100 Gallons of DF-2																	
8	0																	
6	8	0																
4	14	8	0															
2	22	15	7	0														
0	30	22	14	7	0													
-2	48	37	25	18	12	0												
-4	70	57	43	34	25	12	0											
-6	79	64	50	39	30	15	4	0										
-8	86	70	54	43	34	20	7	4	0									
-10	109	89	70	52	45	27	13	9	7	0								
-12	164	123	93	73	57	36	20	15	12	5	0							
-14	186	139	105	82	64	41	24	20	14	8	4	0						
-16	204	150	113	89	70	45	27	22	18	10	6	3	0					
-18	234	171	128	100	79	52	32	27	22	14	9	6	4	0				
-20	271	195	144	113	89	59	37	32	27	18	13	9	7	4	0			
-22	317	223	164	128	100	67	43	37	32	22	17	13	10	7	4	0		
-24	377	258	186	144	113	76	50	43	37	27	21	17	14	10	7	4	0	
-26	427	285	204	157	123	82	54	48	41	30	24	20	17	13	9	6	3	0

Table 5. Blending Ratio for -6.7° to -12° C

Desired Cloud Point (°)	Initial Cloud Point (°C) -6.7	-8.0	-10.0	-12.0
	Gallons of Blending Fuel to Add to 100 Gallons DF-2			
-6.7	0			
-8.0	13	0		
-10.0	32	15	0	
-12.0	59	36	15	0

Table 6. Blended Ratio for -13.33° to -32°C

Desired Cloud Point (°)	Initial Cloud Point (°C)										
	-13.33	-14.00	-16.00	-18.00	-20.00	-22.00	-24.00	-26.00	-28.00	-30.00	-32.00
-13.33	0										
-14.00	6	0									
-16.00	17	12	0								
-18.00	32	25	21	0							
-20.00	70	59	39	21	0						
-22.00	86	76	52	30	7	0					
-24.00	118	100	70	45	17	10	0				
-26.00	164	133	89	57	24	15	12	0			
-28.00	245	195	126	82	39	29	24	14	0		
-30.00	317	245	157	100	50	37	32	21	14	0	
-32.00	425	317	195	123	62	47	41	29	21	12	0

Tables 3 and 4 are for temperatures given in °F, with Table 3 applicable to temperatures 10° F and above; Table 4 is applicable to temperatures 8° F and below. Tables 5 and 6 are for temperatures given in ° C, with Table 5 applicable to temperatures -12° C and above; Table 6 is applicable to temperatures -13.33° C and below.

The blending ratios for 8° F to -10° F and -13.33° C to -24° C are calculated from experimental data obtained in this laboratory. The blending ratios for 20° F to 10° F, -12° F to -26° F, -6.7° C to -12° C, and -26° C to -32° C are based on the following formula derived for use with typical kerosenes:

$$K = 100 \times (B - A)/(B - C) \tag{1}$$

where:

K = Kerosene in blend (percent).
B = Cloud Point Index (CPI) of diesel fuel (DF-2) in blend.
A = CPI of blend.
C = CPI of kerosene.

The Cloud Point Index was determined by Mobil Research and Development Corporation, Paulsboro, New Jersey.

Equation (2) should be used to determine the amount of blending fuel needed to achieve the desired Cloud Point:

$$A = (B/100) \times C \tag{2}$$

where:

A = Gallons of blending fuel to add to achieve desired Cloud Point.

B = Gallons of diesel fuel (DF-2) to be blended (this value is the number of gallons of DF-2 in tank, vehicle, drum, tank car, etc.).

C = Gallons of blending fuel to add to each 100 gallons of DF-2 to achieve desired Cloud Point (this value is read from either Table 3, 4, 5, or 6.).

The following example illustrates the use of Equation (2):

Example: A tank contains 350 gallons of DF-2 from a single lot. The field test shows that the Cloud Point is 6° F. The weather forecast predicts a severe cold front that is anticipated to persist for the next month or longer. The anticipated low is -2° F. How many gallons of blending fuel are needed to achieve the desired Cloud Point? Using Equation (2):

$$A = (B/100) \times C)$$

where:

B = Gallons of DF-2 to be blended (or 350 which is the number of gallons in the tank).

C = Gallons of blending fuel to add to each 100 gallons of DF-2 to achieve desired Cloud Point (or 37 which is the number of gallons indicated in Table 4).

A = (350/100) X 37.

or

A = 129.5 gallons of blending fuel to add to achieve desired Cloud Point.

3. Blending Procedures. Fuel blending consists of two steps: (a) addition of the proper quantity of blending fuel and (b) mixing in order to insure homogeniety. Before addition can be accomplished, the capacity of the tank that will receive the blending fuel, the volume of diesel fuel in the tank, and the volume of blending fuel to be added must be known.

For fuel volumes in excess of 3500 gallons, the fuel temperature should be noted and the volume corrected to 60° F. Care should be taken to insure that addition of the blending fuel does not cause the tank to overflow; in some cases it may be necessary to remove part of the DF-2 prior to addition of the blending fuel. Proper safety procedures, including proper placement of grounding cables, should be followed at all times during addition and mixing.

The order of blending precedence has been established. The preferred location to accomplish blending is in a fuels-dispensing site (as in a Class II Supply Point) or in fuels-dispensing vehicles that utilize their own pumps. The next most desirable is fixed tanks not using pumps (as in elevated tanks). Least preferrable is blending in the using vehicle or equipment. Blending in vehicle fuel tanks should be done only as a last resort as it is imprecise and time consuming. In some cases it may be preferrable to run the vehicle fuel tanks dry and then refuel with fuel that has been blended in a refueling vehicle.

It is important that the addition of blending fuel be metered with as high a degree of precision as is practical. For small volumes, a graduated cylinder can be used. Larger volumes require less precision so that incremental quantities in, for example, 5-gallon cans are allowable. The most practical way of metering fuel for large capacity tanks is by means of a pump and flowmeter. Fuel-dispensing vehicles are equipped with such metering equipment, and they can be used for metering blending fuel in their own tanks, in other vehicles, or in fixed systems. A 55-gallon drum equipped with manual pump and a metering stick makes an effective metering device.

a. Blending in Fuels-Dispensing Vehicles. Fuels-dispensing vehicles include: tank trucks (M49 series and M559), fuel-servicing tank semi-trailers (M131 series), and tank and pump units. All such vehicles are equipped with fuel-transfer pumps driven by an auxiliary engine or by a power takeoff. Addition may be made by the use of 5-gallon cans or 55-gallon drums. Larger volumes will require using the vehicle's own pump and flowmeter with the inlet connected to the blending fuel source and the outlet connected to a hose going to the access cover on top of the tank (Figure 1). Mixing is accomplished by reconnecting the pump inlet hose to the vehicle and recirculating the fuel for a minimum of 15 minutes (Figure 2).

b. Blending in 55-Gallon Drums. Blending fuel can be added by pouring directly into the drum as measured by a graduated cylinder or a 5-gallon can. Mixing can be accomplished by rolling the drum.

c. Blending in Fixed Gravity Feed Tanks Not Equipped with Fuel-Transfer Pumps. Blending fuel can be added by hand or by use of the pump and meter of a fuels-dispensing vehicle (Figure 3). Mixing is by recirculating the fuel from the tank outlet to the tank truck pump inlet (Figure 4). Mixing should be a minimum of 15 minutes.

d. Blending in Tank Cars. Tank cars, foreign and domestic, are usually bottom loaded. Blending fuel can be metered by using a fuels-dispensing vehicle. If the tank car is to be transported soon, no special mixing after addition will be necessary as the motion of the train should be sufficient. External mixing equipment will have to be used for a stationary car; the manhole in the dome will have to be removed. A line coming from a pump outlet can be connected through the manhole into the tank compartment. Mixing should be a minimum of 15 minutes.

e. Blending in Underground Tanks (Service Station Outlets). Addition into these tanks can be accomplished by gravity feed from a fuels-dispensing vehicle using the meter but not the pump. Mixing with the service station pump is possible but usually inconvenient, as the pump meter reading is used as the basis for fuel inventory control. The use of an auxiliary fuel-transfer pump or a vehicle pump to provide recirculation will require access to two tank manholes (Figure 5). Mixing should be a minimum of 15 minutes.

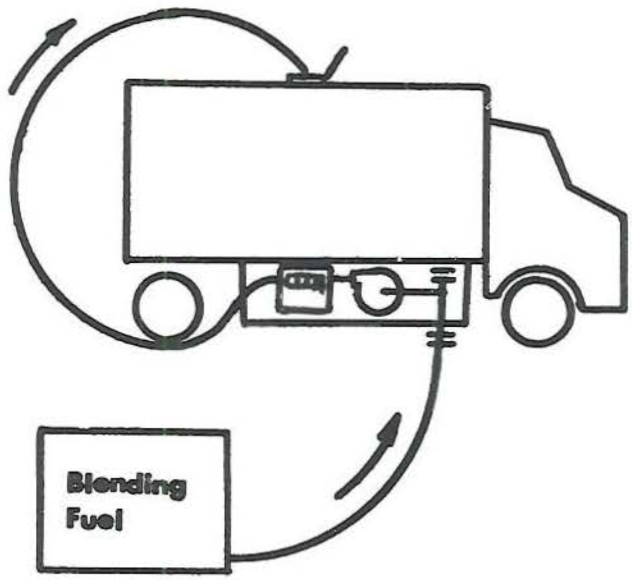

Figure 1. Addition of blending fuel to fuels-dispensing vehicle.

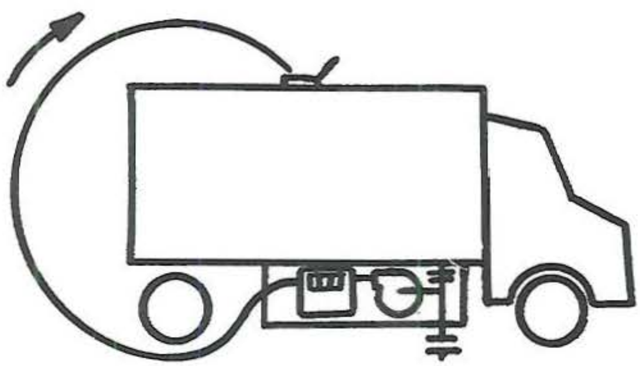

Figure 2. Mixing of blending fuel in fuels-dispensing vehicle.

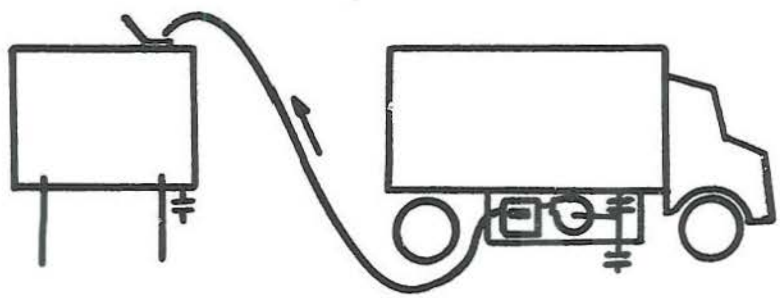

Figure 3. Addition of blending fuel to fixed gravity feed tank not equipped with fuel-transfer pumps.

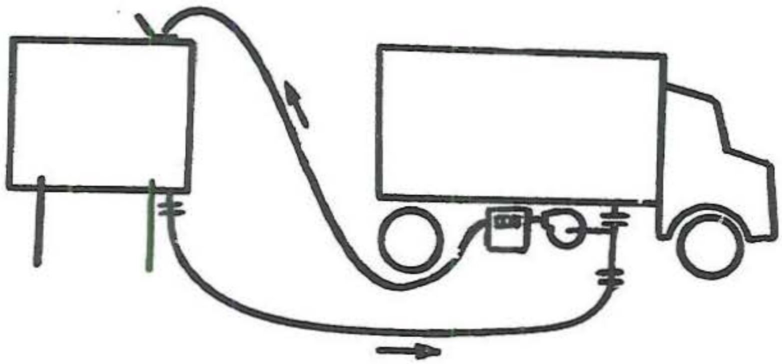

Figure 4. Mixing of blending fuel in fixed gravity feed tank not equipped with fuel-transfer pumps.

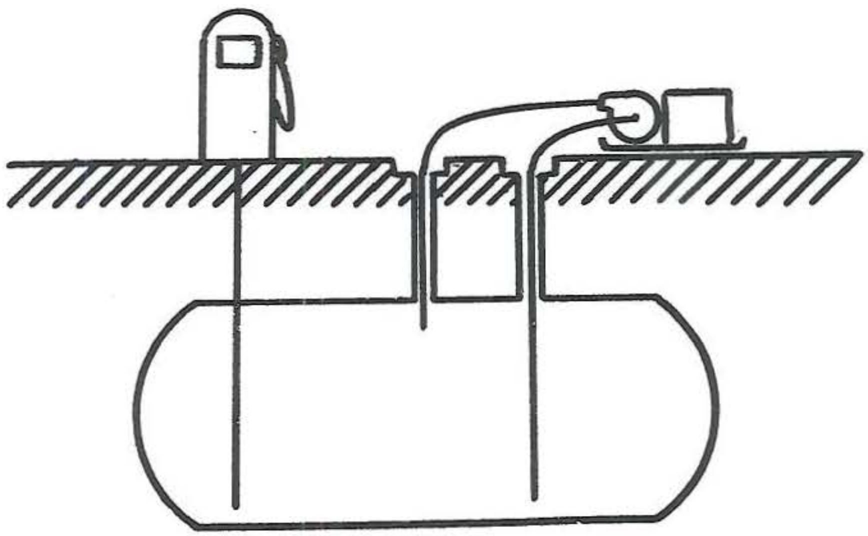

Figure 5. Mixing of blending fuel in underground tank (service station outlets).

f. Blending in Collapsible Tanks and Drums Connected to a Manifold System. This procedure covers all collapsible containers (i.e., 3,000-, 10,000-, 50,000-gallon pillow tanks; 500-gallon collapsible drum) installed in a manifold system such as in a Fuel System Supply Point. Blending can be accomplished only by pumping fuel out of one tank or set of tanks while pumping into another while injecting blending fuel. The injection can be made in the piping or hose system just upstream of the circulating pump (Figure 6).

g. Blending in Using Equipment and Vehicles. Blending in the fuel tanks of using equipment and vehicles should be undertaken only as a last resort. It may be more practical to run the engines until the tanks are practically empty, then refuel with the blended fuel. When fuel blending is deemed necessary, care must be taken in metering out the required quantity of blending fuel, as the fuel tank capacities are usually limited. Mixing usually can be accomplished simply by running the engine, as most fuel systems are designed to recirculate continuously back to the fuel tank.

h. Blending in Ground Support Equipment Fuel Tanks (i.e., Generators, Pumps, Air-Conditioning Equipment). Always make sure that the equipment is designed to run on diesel fuel (diesel engine or gas turbine). Many of the fuel tanks are equipped with drains so that excess fuel can be removed easily. Blending fuel is added in fairly precise amounts using a graduated cylinder or a manual pump in a 55-gallon drum (Figure 7). Mixing can be accomplished by running the engine for a minimum of 5 minutes.

i. Blending in Vehicle Fuel Tanks. Most vehicle fuel tanks do not have drains; therefore, excess fuel must be removed in other ways. For most trucks, a siphon can be used. Tactical tracked vehicle fuel tanks are usually constructed so as to preclude siphoning. The engines of these vehicles may have to be run to lower the fuel level. Some tactical vehicles (M48, M60) have two fuel tanks with no crossover; the driver controls fuel-switching valves. These vehicles may only have to have one fuel tank undergo blending; the one that is intended to be used during the cold weather period. Longer runs will require blending in both tanks. The M1 tank has four tanks: two rear tanks are linked by a crossover and feed fuel to the engine; the two front tanks feed fuel to the rear tanks (Figure 8).

4. Fuel Blending Examples. The following are examples of how fuels are blended:

a. Example 1. An M49C tank truck with a capacity of 1200 gallons is filled with 1050 gallons of DF-2 having an unknown Cloud Point. The weather report indicates that the temperature is expected to go down to 0° F (-17.8° C) for an extended period of time starting that evening. The M49C is scheduled for operational use by the next morning. What action should be taken to ensure that the vehicles and equipment refueled from this vehicle will be operatonal?

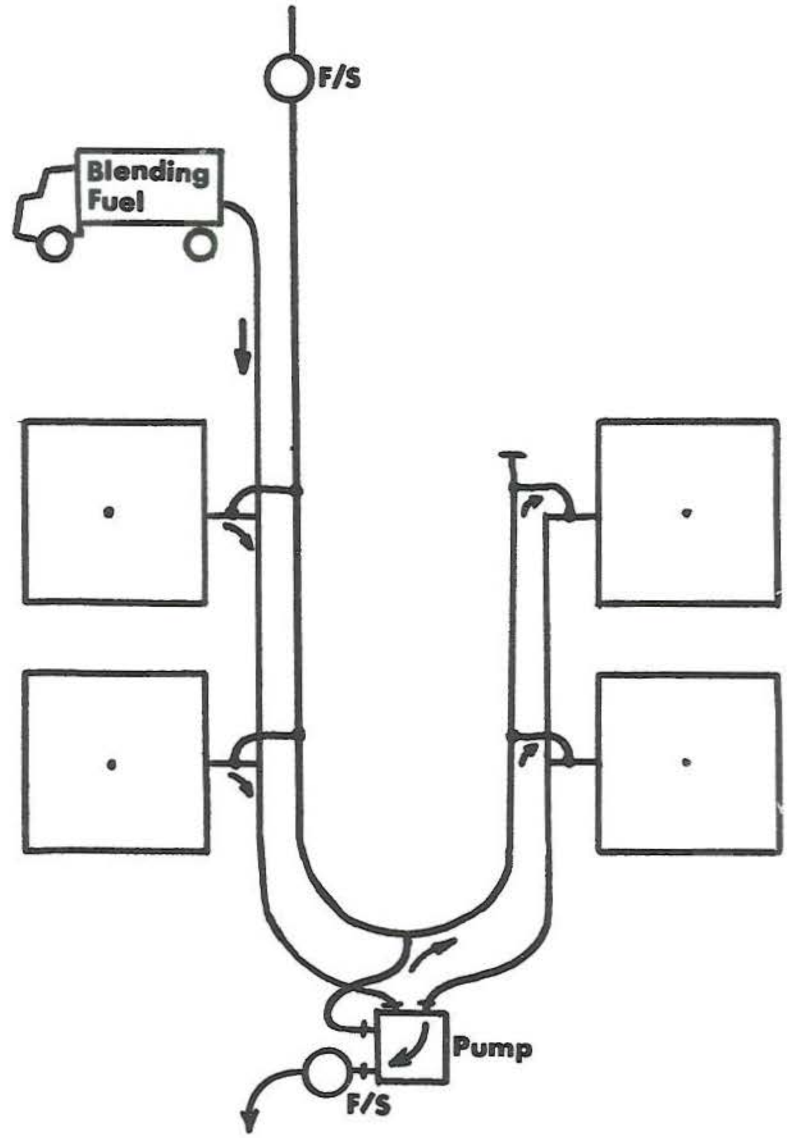

Figure 6. Addition and mixing of blending fuel in collapsible tanks and drums connected to a manifold system.

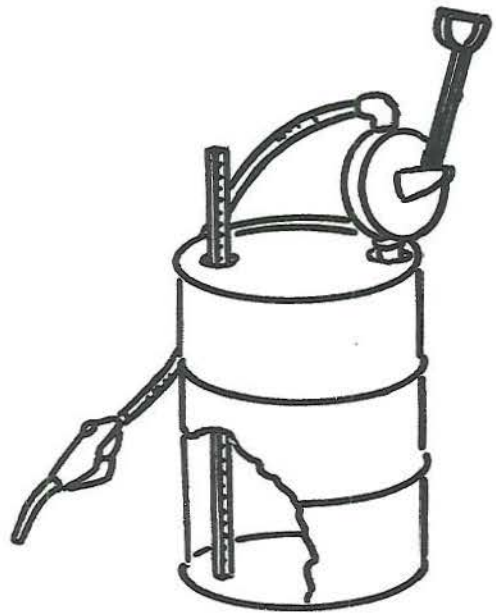

Figure 7. Addition of blending fuel using manual pump and metering stick.

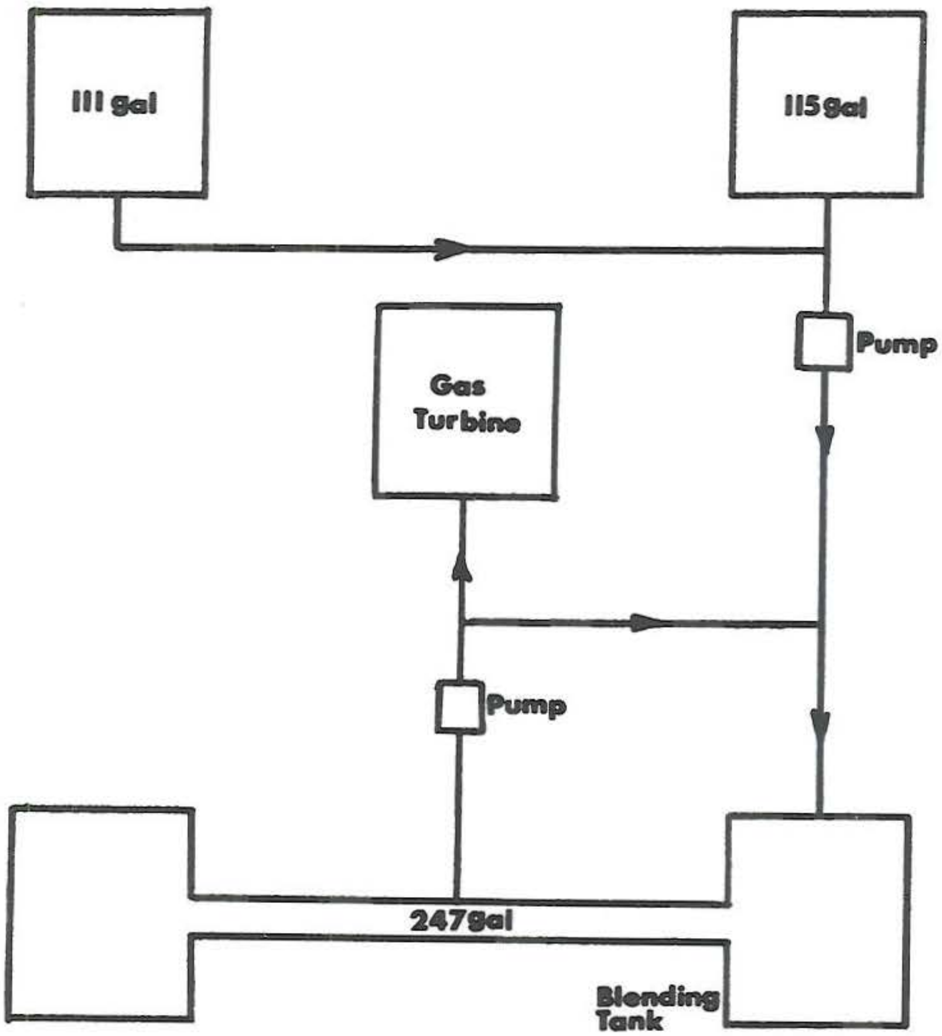

Figure 8. M-1 tank fuel system.

The operator checks the source of the fuel in the tank truck to determine if there is some record of Cloud Point. When none is found, he decides to determine the Cloud Point in the field. A fuel sample is taken using a thief sampler through the access cover of the tank truck. The field method indicates an approximate Cloud Point of 8° F (-13.3° C). This means that the Cloud Point of the DF-2 must be depressed by 8° F. Table 3 indicates that it will take 30 gallons of blending fuel for each 100 gallons of DF-2 to achieve the desired Cloud Point. For 1050 gallons, this means that (1050/100) X 30 or 315 gallons of blending fuel is needed. However, if this much is added it will mean that the new total volume will be 1050 + 315 = 1365 gallons—more than the capacity of the tank truck. Some of the fuel will have to be removed from the trunk. The operator pumps out 200 gallons of the DF-2 through the fuels-dispensing pump. The new volume of blending fuel to be added is 255 gallons (850/100) X 30. The new total volume, after mixing, will be 850 + 255 = 1105 gallons. The blending fuel is mixed by placing the discharge hose into the access cover and recirculating the fuel for 15 minutes.

b. Example 2. A check of the fuel gauges on an Abrams (M1) tank indicates the following: Rear fuel tanks are one-quarter full; front fuel tanks are both full. The diesel fuel in the fuel tanks came from a lot that measured a 4° F Cloud Point. The M1 is expected to be engaged in exercises that will take it into areas where the temperature may drop as low as -4° F for an extended period of time. What action must be taken to ensure that the M1 tank will remain operational?

After careful consideration, the operator decides that all DF-2 lots including those already in tactical vehicles must have their Cloud Points adjusted to meet the predicted low temperatures. The M1 tank is designed to feed fuel from the rear tanks (capacity 247 gallons) to the turbine engine; the two front tanks feed fuel *only* to the rear tanks. Since there is no recirculation of fuel in the front tanks, fuel blending can be done only in the rear tanks. Table 3 indicates that it will take 43 gallons of blending fuel for every 100 gallons of DF-2 to lower the Cloud Point to -4° F. It is felt that the forthcoming exercise should not consume more fuel than can be held by the rear tanks. Sufficient quantity of DF-2 is pumped from the front tanks to the rear tanks using the internal fuel pumps. There must be enough room left in the rear tank to receive the blending fuel. This amount can be calculated by using the ratio of 43/100 = X/247 or X = (43/100) X 247 = 106 gallons. Since 106 gallons must be allowed in the rear tanks, sufficient fuel is transferred from the front tanks until the rear tank gauge reads 141/247 = 0.57 or a little over half full. Then, 106 gallons of blending fuel is added by means of a refueling vehicle. The engine is run at idle for 15 minutes to provide mixing.

III. EXPERIMENTAL

5. Materials. The following materials are needed for the Field Test Method for Approximate Cloud Point:

a. All fuel samples used in these experiments were industry supplied:

Diesel Fuel (VV-F-800), Grade DF-2, Cloud Point +8° F (-13.33° C).

Kerosene (ASTM D3699), Cloud Point -59° F (-50.56° C)

b. Sodium chloride (table salt) may be laboratory grade or may be that obtained from a mess hall, commissary, or food market.

c. A supply of ice or snow is needed. Ice may be obtained from a refrigerator, ice plant, or from frozen waters in winter. Ice should be crushed by means of an ice crusher or simply by using a hammer.

d. A 300- to 500-ml beaker or other open container wrapped with a towel or an insulated cup (Figure 9) to be used to contain the ice-salt bath.

e. Stirring rod or stick (pen or pencil acceptable) used to stir the ice-salt bath.

f. Thermometer, immersion, graduated, glass bulb or dial type which covers the approximate range of 32° F to -4° F (0° C to -20° C) in single-degree increments; ASTM No. 5C or No. 5F is recommended (Figure 9).

g. A test tube which measures approximately 15 to 20 mm outside diameter. The thermometer should be small enough to fit inside the test tube.

6. Sampling. Fuel samples should representative of the lot or batch to be tested. One should avoid sampling from the bottom of tanks and containers as the presence of water bottoms may invalidate the results. A tube or thief sampling device should be used if possible. If a bottom sample must be taken, allow the fuel or run out for a new minutes before sampling.

Figure 9. Materials needed to field test cloud point of DF-2 diesel fuels.

7. Field Test Method for Approximate Cloud Point. All Cloud Points were obtained in a beaker or cup containing crushed ice or snow. Approximately 2 teaspoons of salt were added (Figures 10 or 11) and stirred until a slush began to form (Figure 12). The sample of fuel to be tested was poured into a test tube. A thermometer was inserted into the test tube until the bulb was completely immersed. The test tube was placed in the ice-salt bath (Figures 13 or 14). The bath was stirred until the temperature was lowered to the point where a hazy area was seen at the bottom of the test tube. The test tube was periodically removed from the bath to observe the change (Figure 15). Fuel samples, before the Cloud Point (Figure 16), at the Cloud Point (Figure 17), and past the Cloud Point (Figure 18), are depicted. The observed Cloud Point was then recorded. If no Cloud Point is observed, it may mean that it is below the lower limit of this test method. The test should be repeated if any doubt exists. More easily distinguishable Cloud Points determined under the conditions of this test are shown in Figures 19 through 22. It should be noted that these diesel fuel samples are of different colors from the diesel fuel shown in Figures 13 through 18.

IV. CONCLUSIONS

This method of test covers the determination of the approximate value of the cloud point for hydrocarbon fuels in the temperature ranges at 3° F (-16° C) and above. It is intended primarily for use where no laboratory facilities are available. The apparatus consists of items that usually can be obtained easily from local sources. The fuel sample is cooled by an ice-salt bath until the temperature is reached when haziness is first observed. The temperature is recorded representing the approximate Cloud Point.

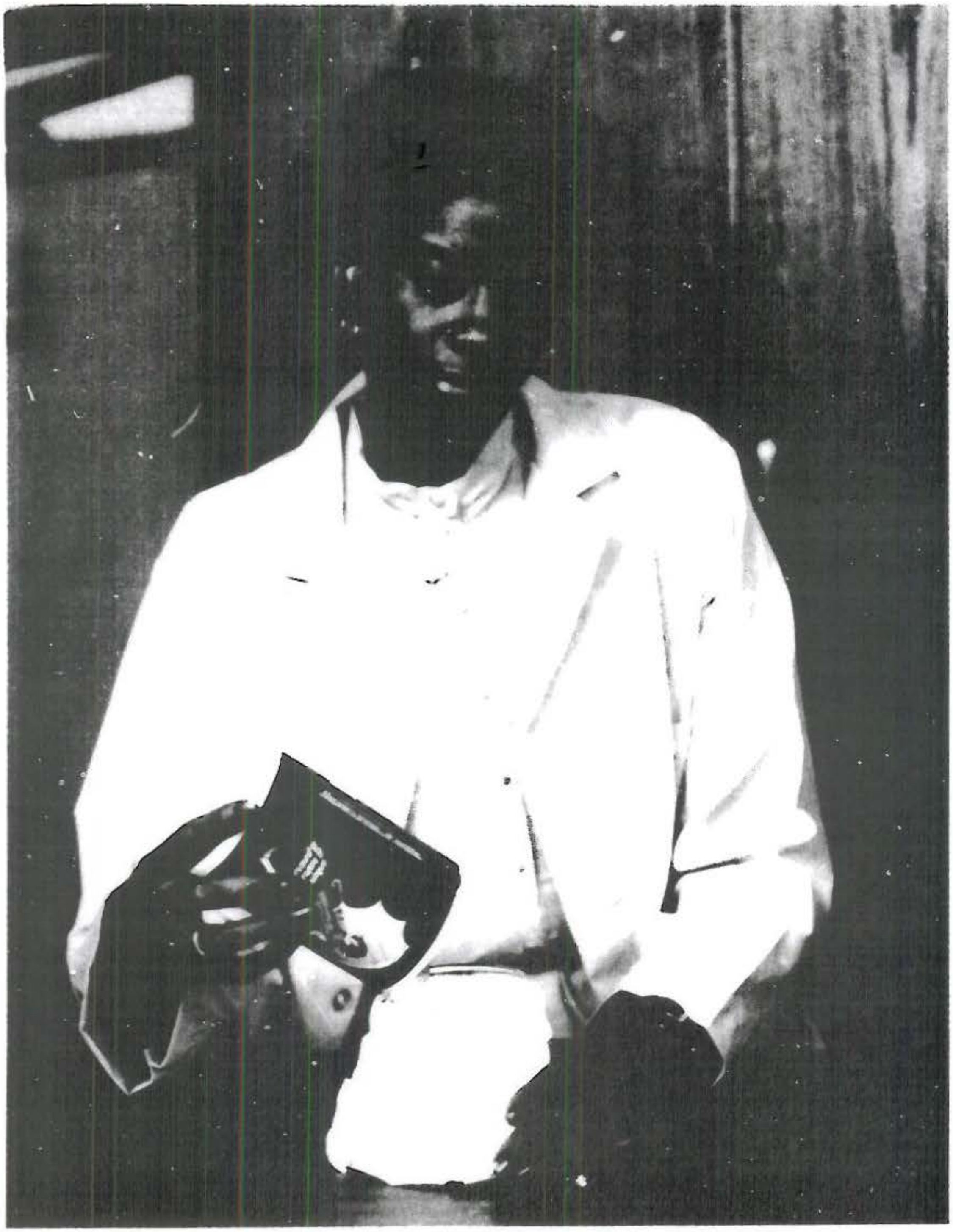

Figure 10. Addition of salt to beaker containing crushed ice or snow.

Figure 11. Addition of salt to cup containing crushed ice or snow.

Figure 12. Formation of ice-salt slush bath.

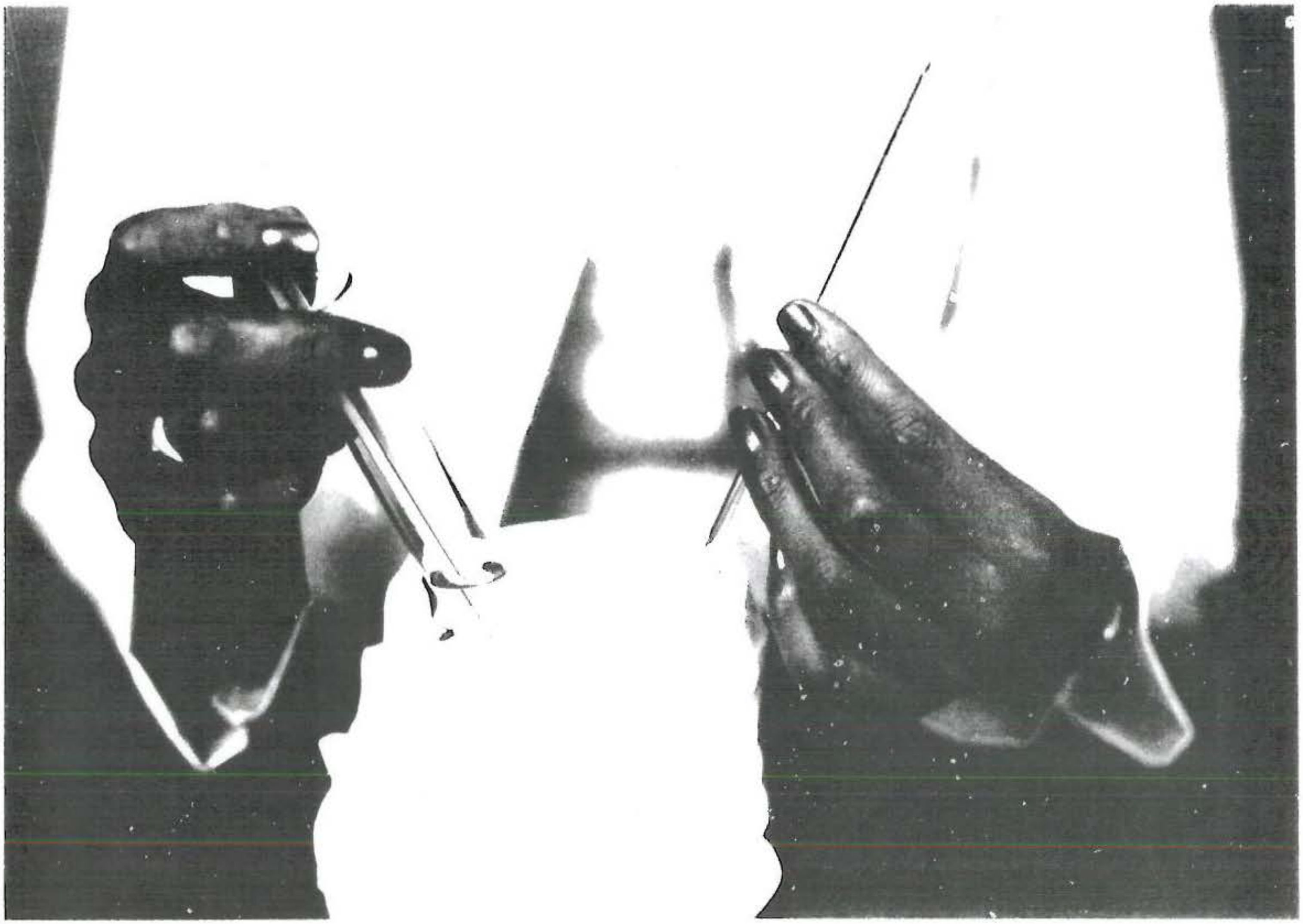

Figure 13. Immersion of test tube into ice-salt bath in beaker.

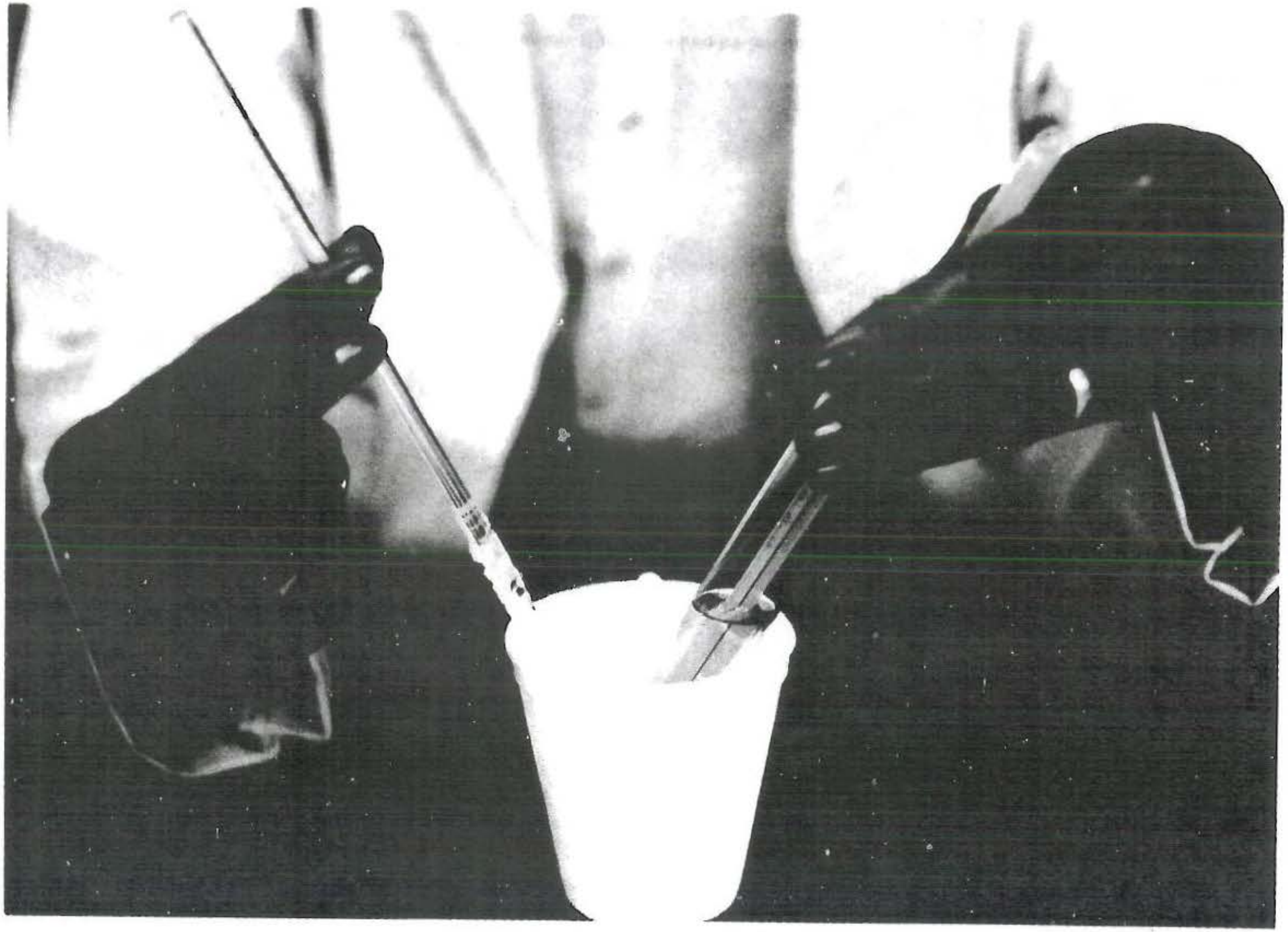

Figure 14. Immersion of test tube into ice-salt bath in cup.

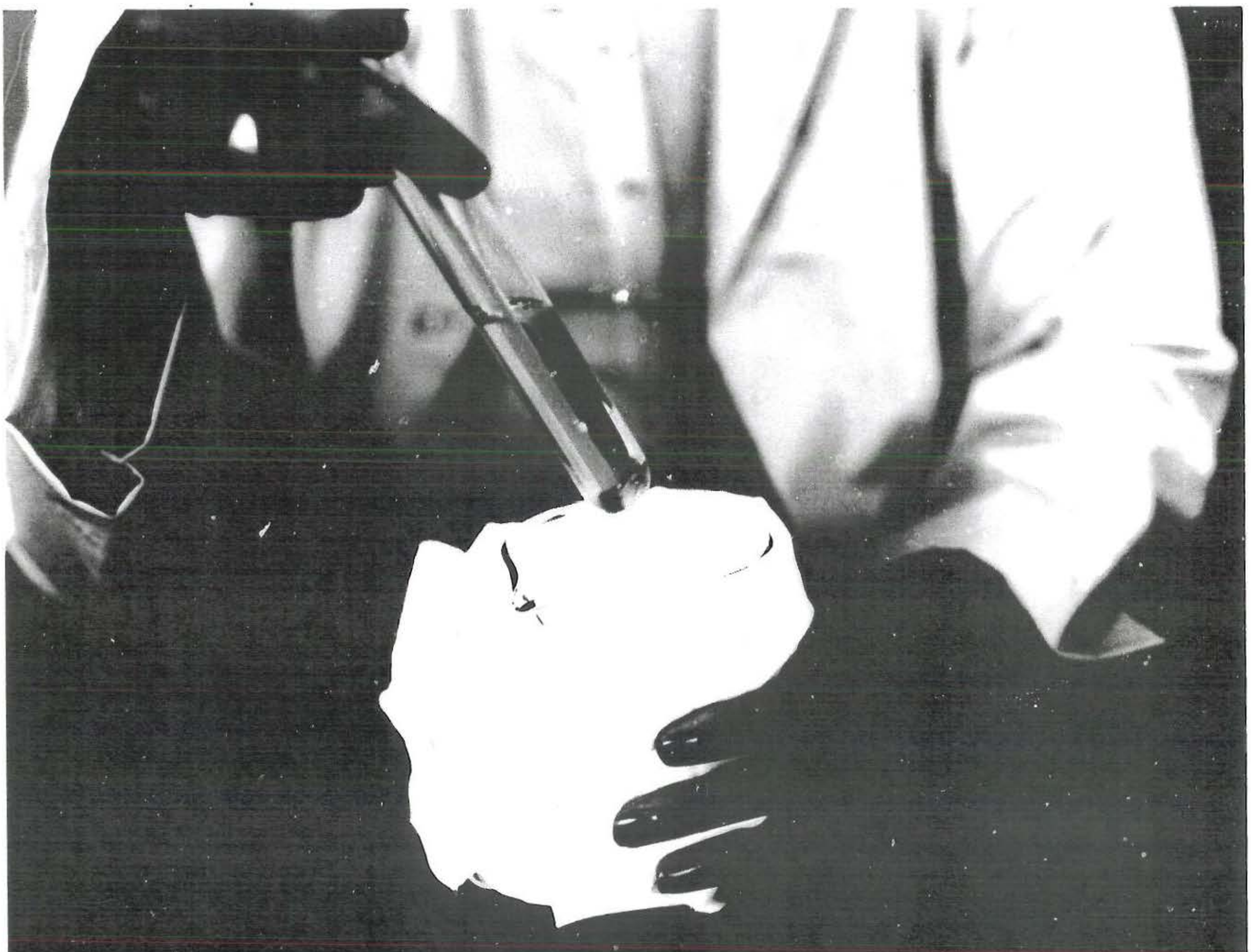

Figure 15. Removal of test tube from bath to observe any change.

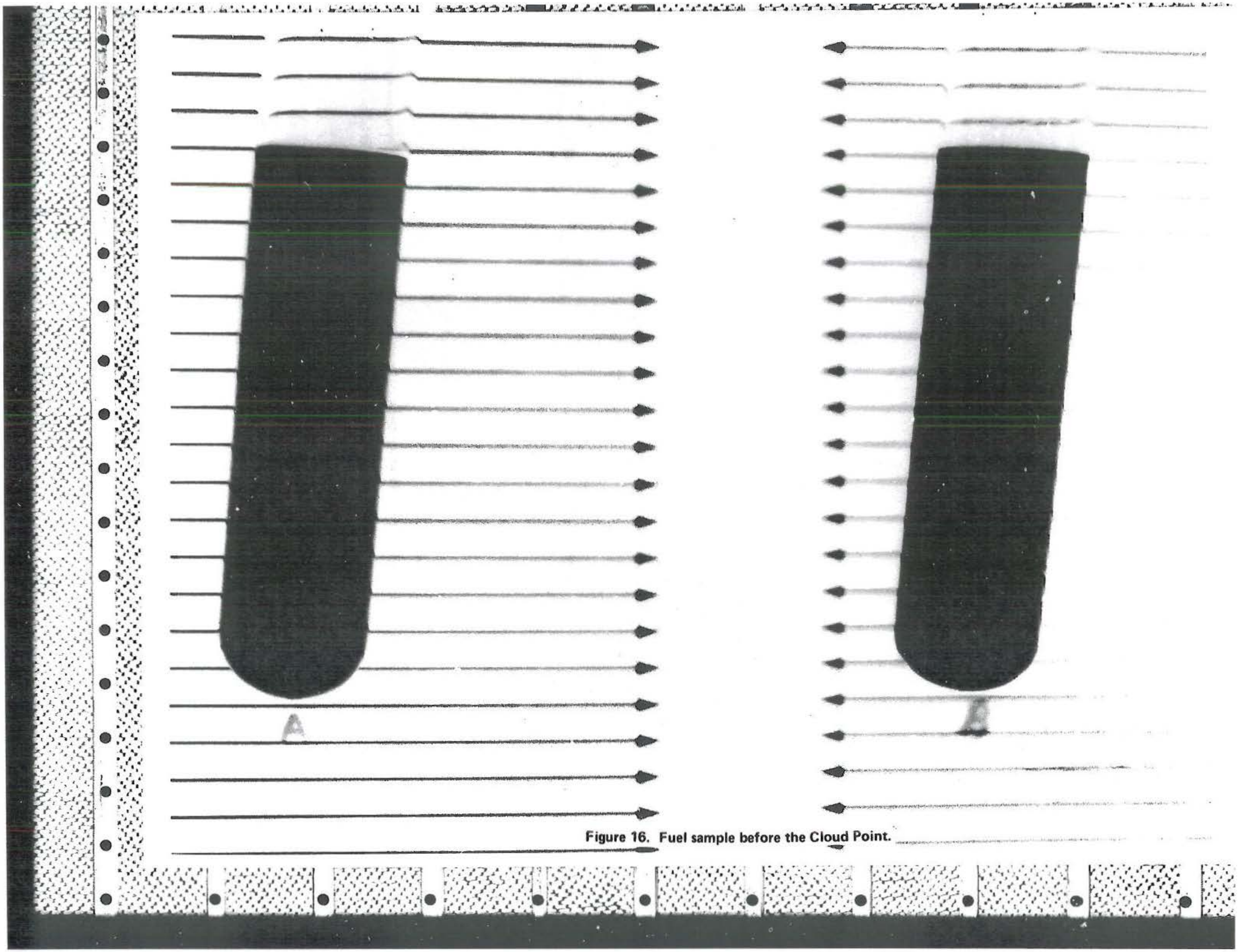

Figure 16. Fuel sample before the Cloud Point.

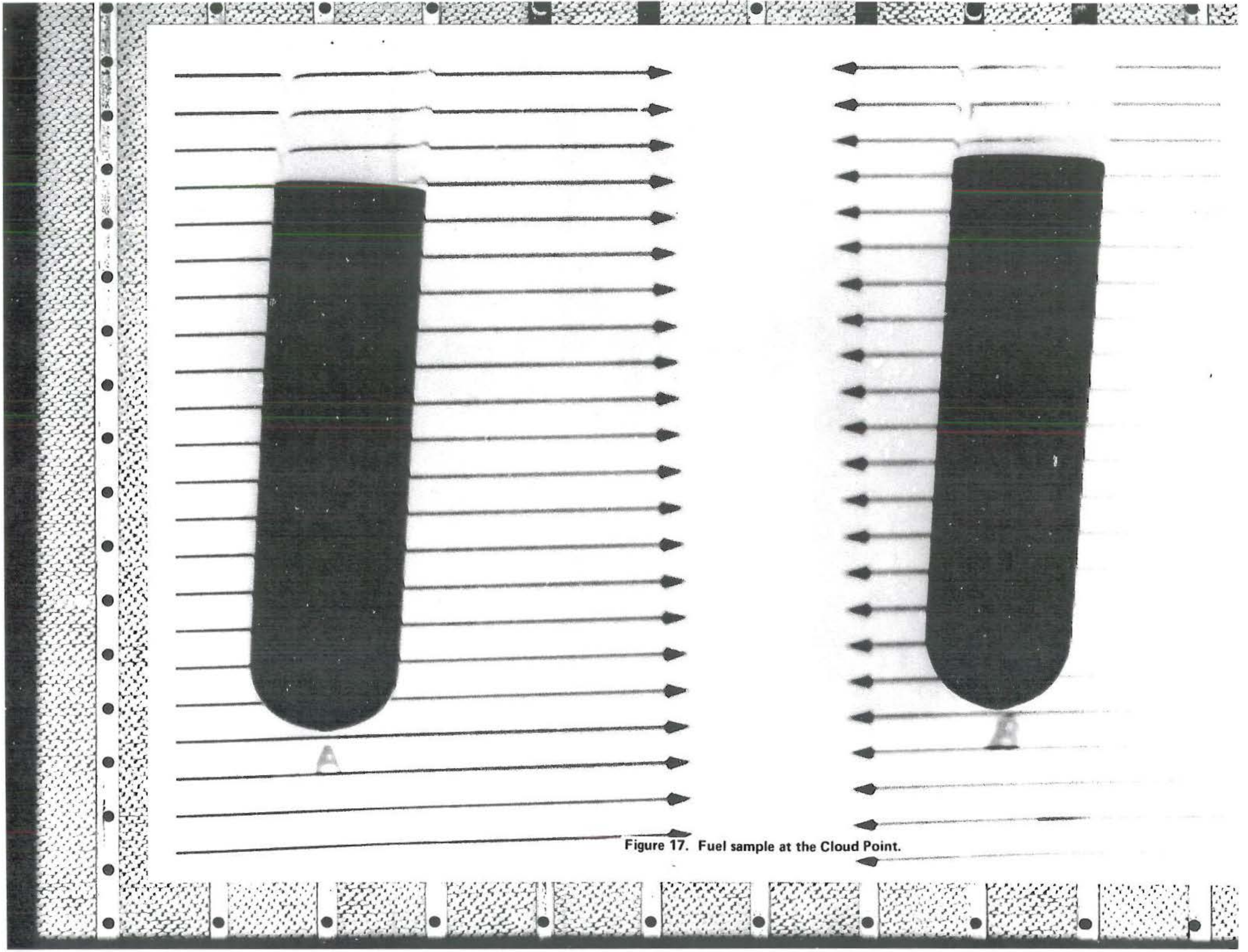

Figure 17. Fuel sample at the Cloud Point.

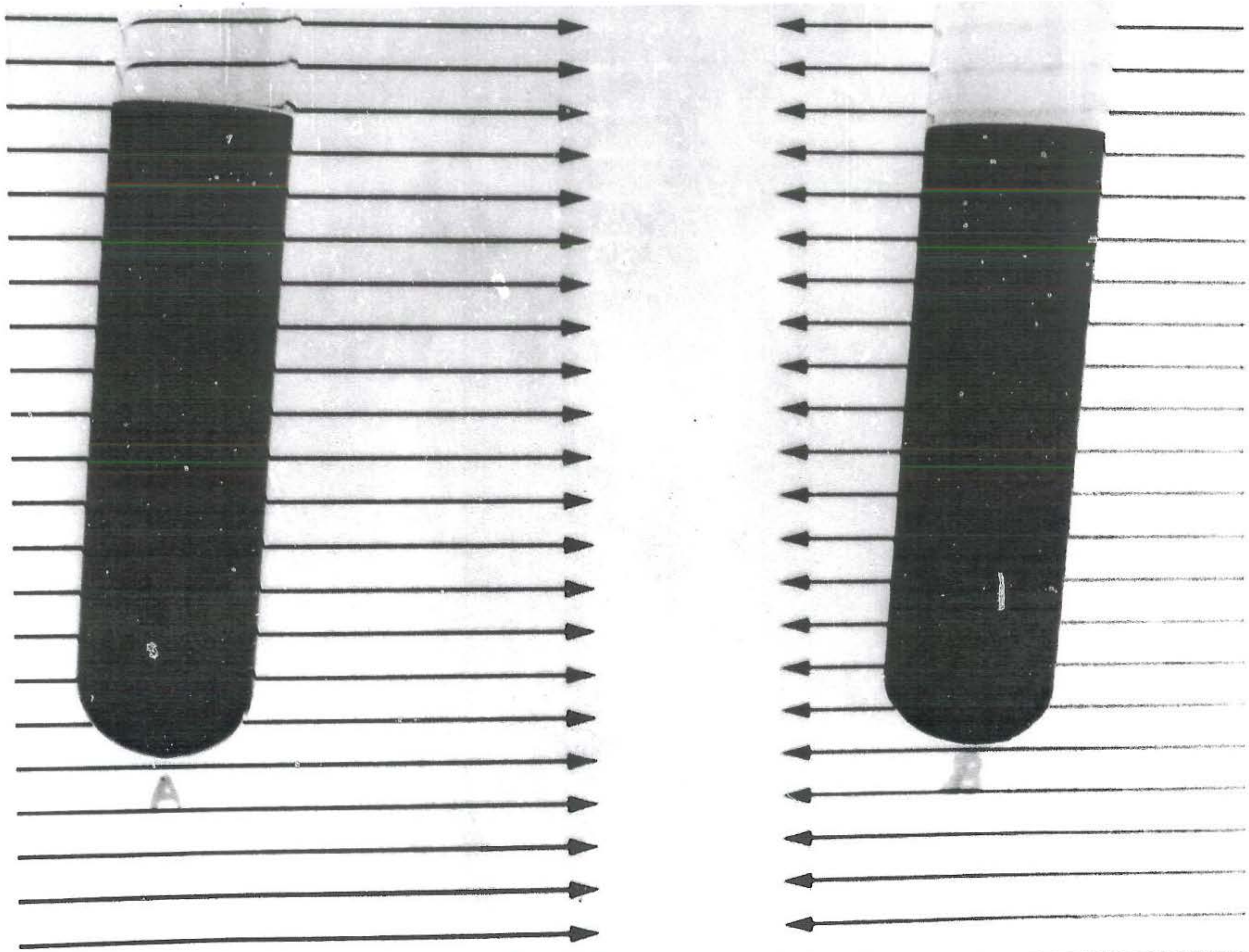

Figure 18. Fuel sample past the Cloud Point.

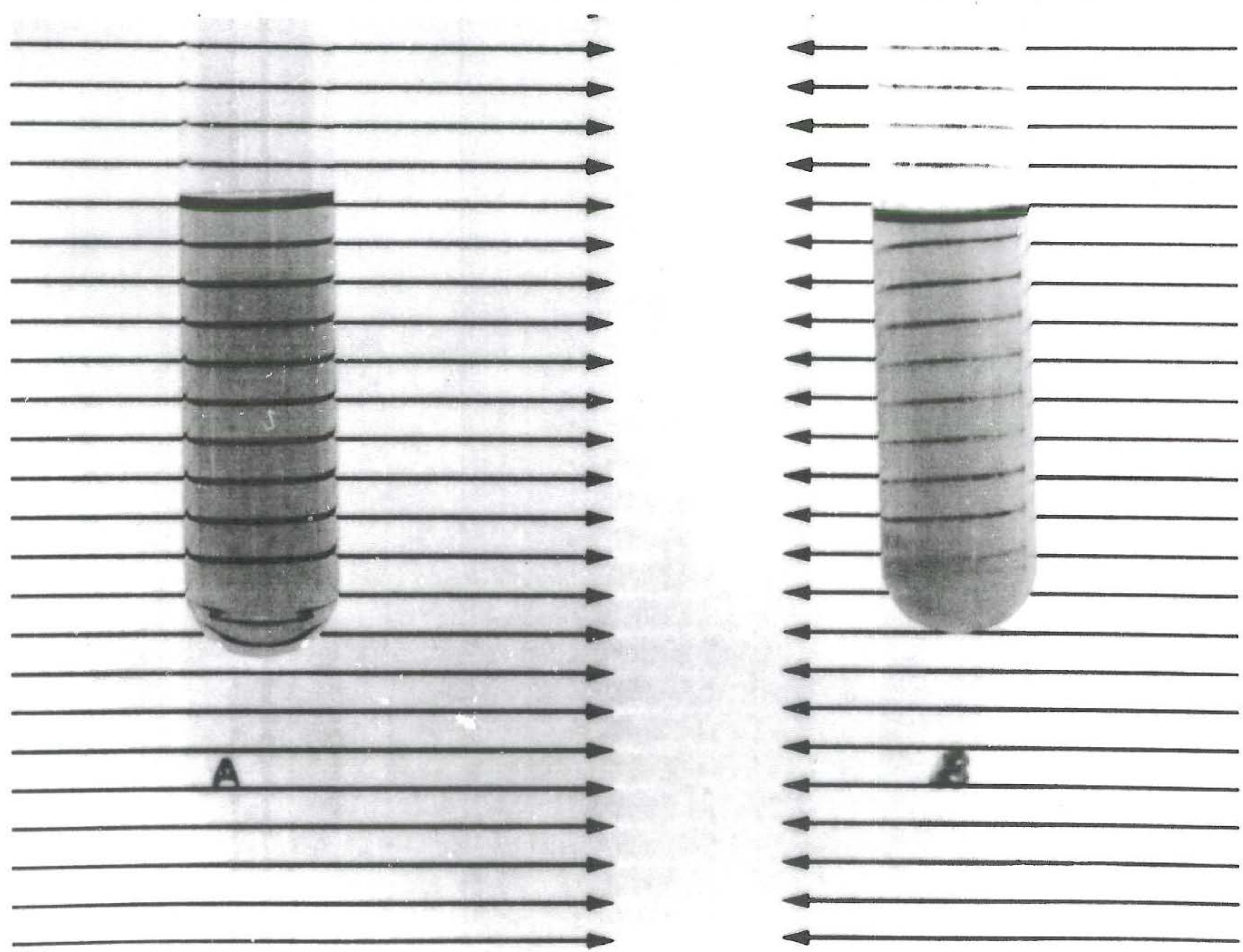

Figure 19. Sample of yellow fuel at the Cloud Point.

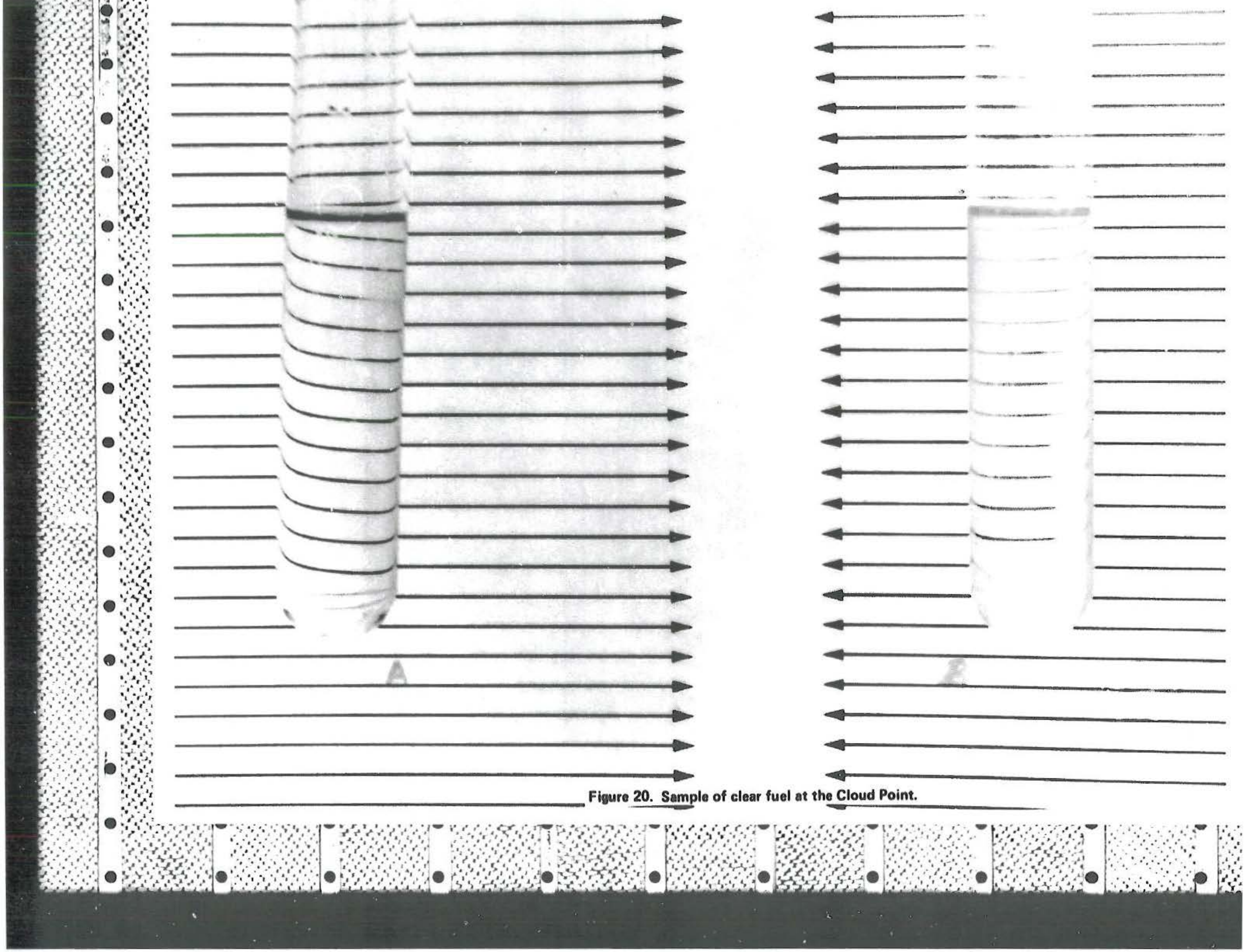

Figure 20. Sample of clear fuel at the Cloud Point.

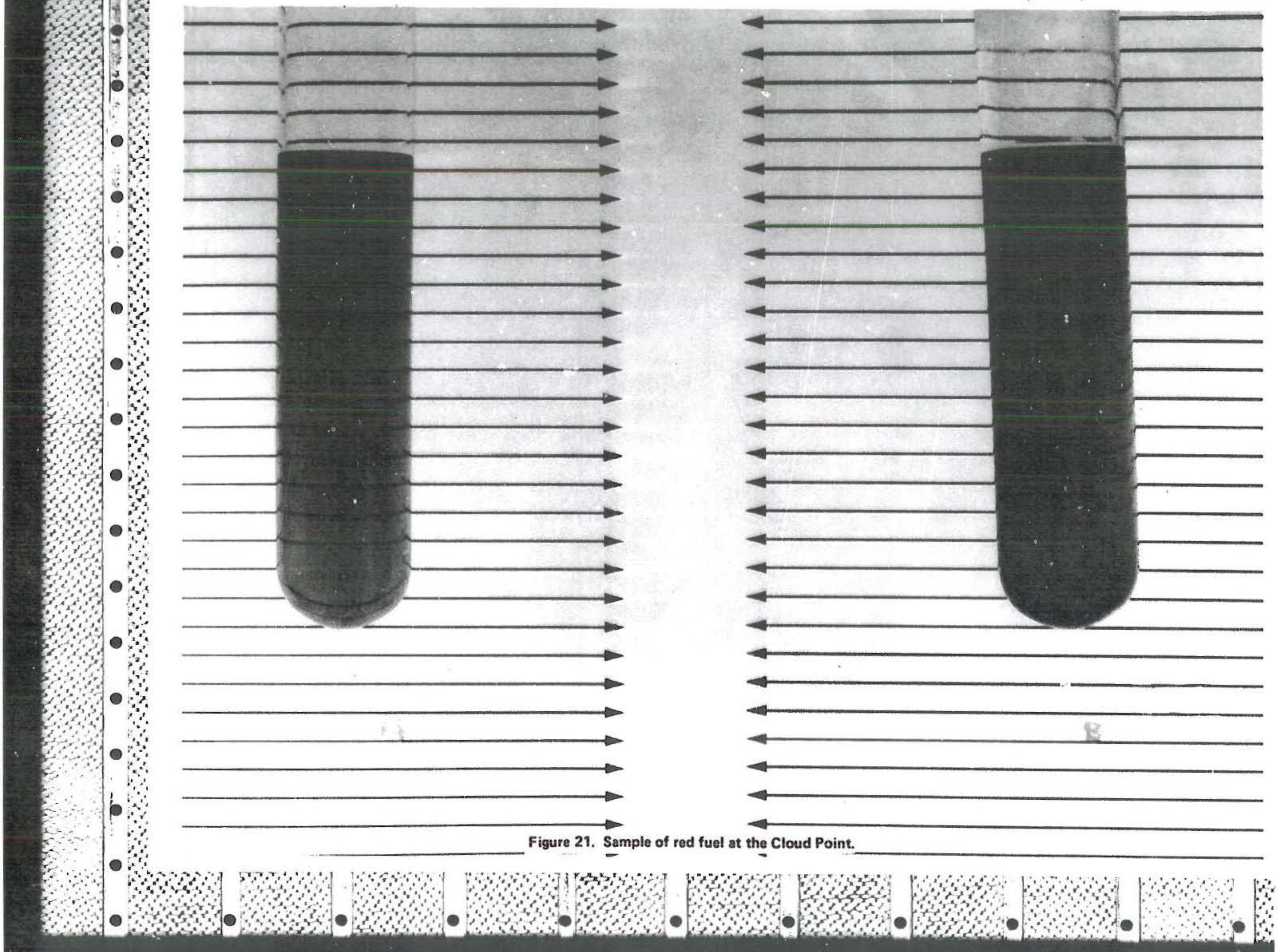

Figure 21. Sample of red fuel at the Cloud Point.

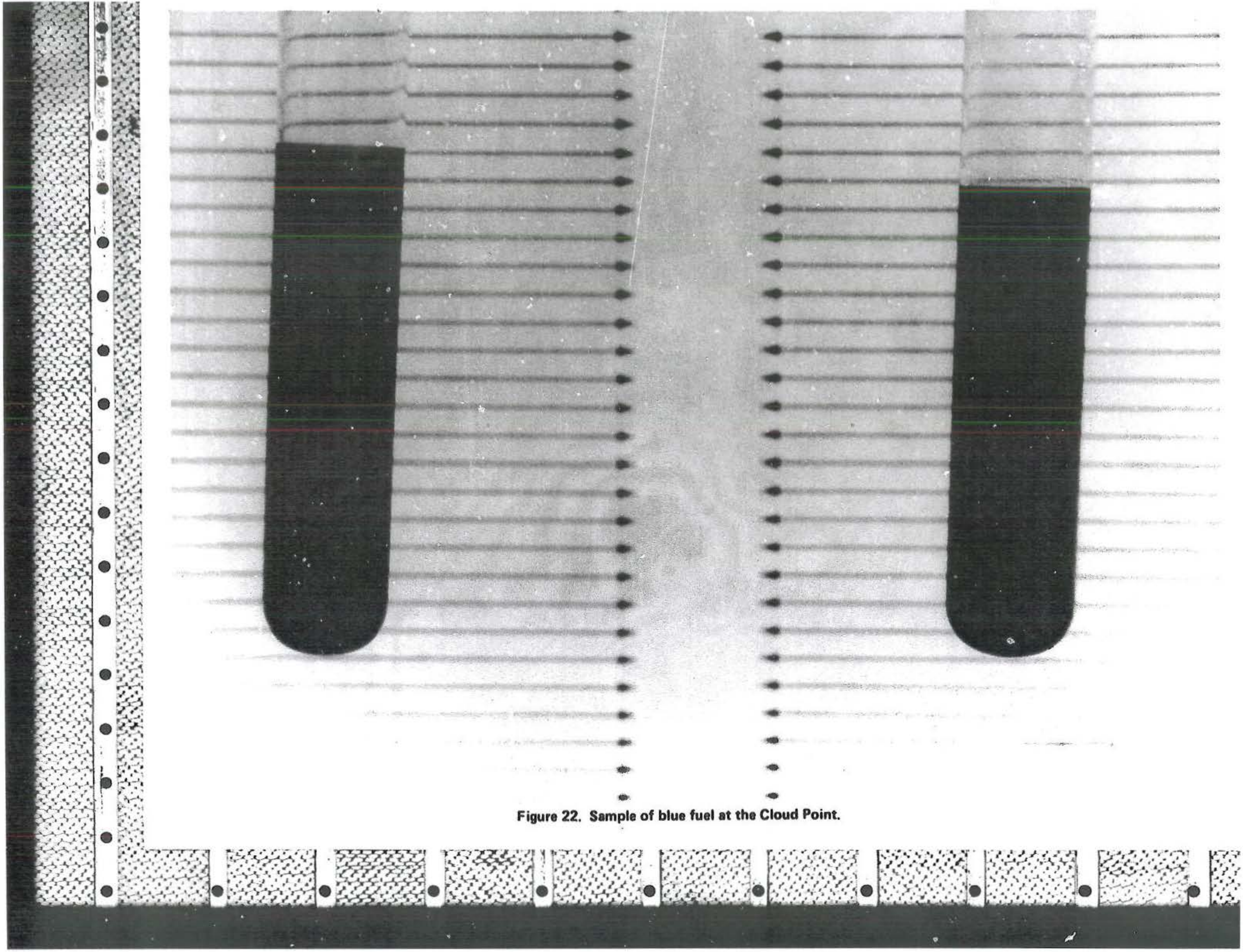

Figure 22. Sample of blue fuel at the Cloud Point.

LIST OF ABBREVIATIONS

ASTM — American Society for Testing and Materials

CONUS — Continental United States

DF-2 — Diesel Fuel, Grade DF-2 (VV-F-800)

FSII — Fuel System Icing Inhibitor, MIL-I-27686 (Ethylene Glycol Monomethyl Ether) or MIL-I-85470 (Di-ethylene Glycol Monomethyl Ether)

ml — Milliliter

N/A — Not applicable

NSN — National Stock Number

OCONUS — Outside the Continental United States

PX — Post Exchange

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